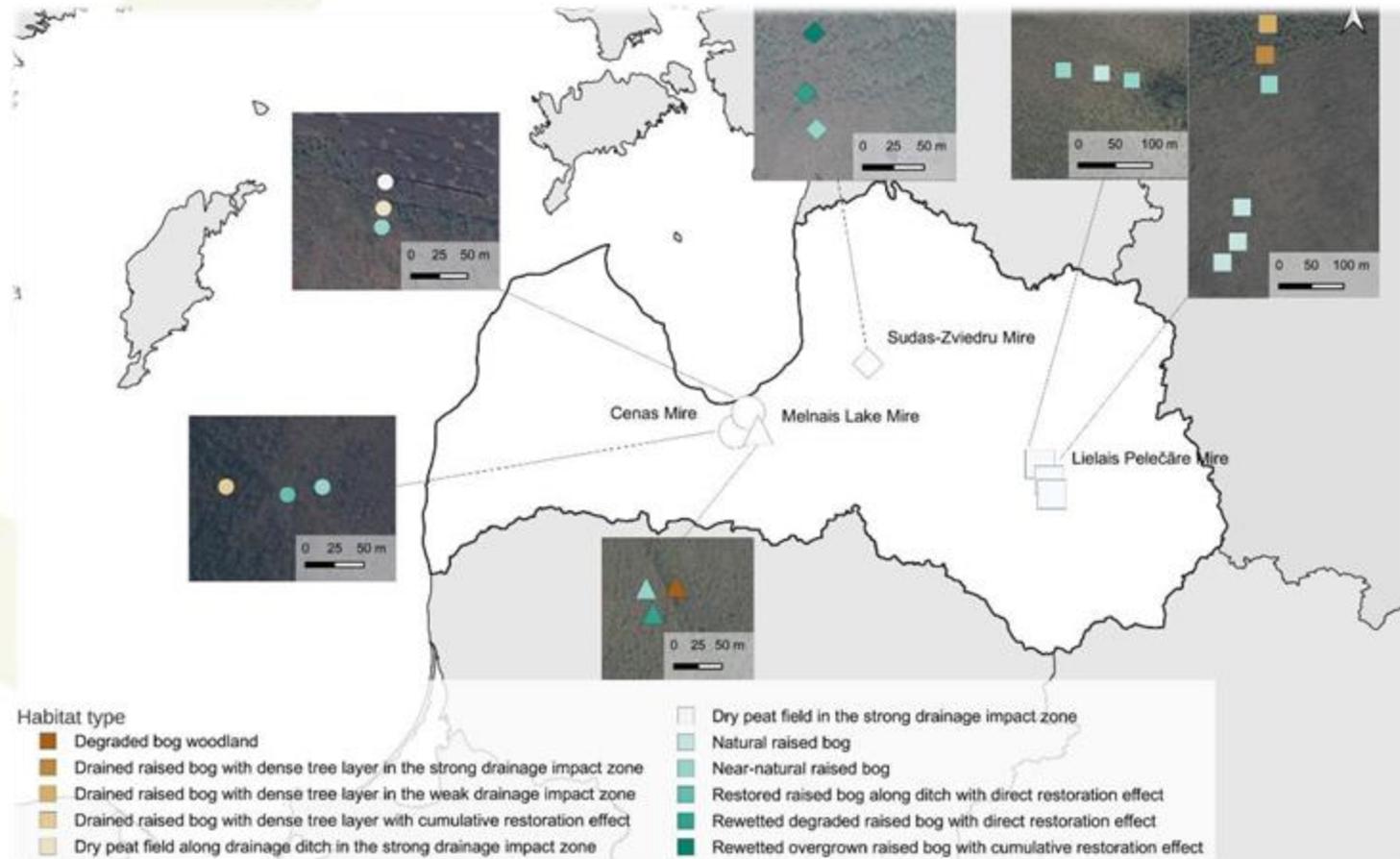EU LIFE Program project
Peatland restoration for greenhouse gas emission reduction and carbon sequestration in the Baltic Sea region
101074396 - LIFE21-CCM-LV-LIFE PeatCarbon

Project Steering Group Meeting
November 14, 2025

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Latvian State Forest Research Institute "Silava"

Rewetting and restoration case study (LIFE PeatCarbon)

Habitat type

- Degraded bog woodland
- Drained raised bog with dense tree layer in the strong drainage impact zone
- Drained raised bog with dense tree layer in the weak drainage impact zone
- Drained raised bog with dense tree layer with cumulative restoration effect
- Dry peat field along drainage ditch in the strong drainage impact zone

- Dry peat field in the strong drainage impact zone
- Natural raised bog
- Near-natural raised bog
- Restored raised bog along ditch with direct restoration effect
- Rewetted degraded raised bog with direct restoration effect
- Rewetted overgrown raised bog with cumulative restoration effect

Sudas-Zviedru Mire

Cenas Mire   Melnais Lake Mire

Lielais Pelečāre Mire

11 habitats

4 mires

7 sites

21 plots

Rewetting and restoration case study Habitats

Pristine raised bog:
- **Natural**
- **Near-natural**

Degraded (drained):
- Peat field
  - Strong DIZ
  - Strong DIZ by ditch
- Tree cover
  - Strong DIZ
  - Weak DIZ
  - Woodland

Rewetted:
- With restoration effect
  - Not overgrown
  - Overgrown
  - Dense tree layer
- Restored

Near-natural raised bog

Natural raised bog

Rewetting and restoration case study Habitats

Pristine raised bog:
- Natural
- Near-natural

Degraded (drained):
- **Peat field**
    - **Strong DIZ**
    - **Strong DIZ by ditch**
- Tree cover
    - Strong DIZ
    - Weak DIZ
    - Woodland

Rewetted:
- With restoration effect
    - Not overgrown
    - Overgrown
    - Dense tree layer
- Restored

Peat field
strong drainage impact zone

Peat field
strong drainage impact zone by ditch

Rewetting and restoration case study Habitats

Pristine raised bog:
- Natural
- Near-natural

Degraded (drained):
- Peat field
  - Strong DIZ
  - Strong DIZ by ditch
- **Tree cover**
  - **Strong DIZ**
  - **Weak DIZ**
  - **Woodland**

Rewetted:
- With restoration effect
  - Not overgrown
  - Overgrown
  - Dense tree layer
- Restored

Dense tree layer in
srong drainage impact zone

Dense tree layer in
weak drainage impact zone

Rewetting and restoration case study Habitats

Pristine raised bog:
- Natural
- Near-natural

Degraded (drained):
- Peat field
  - Strong DIZ
  - Strong DIZ by ditch
- Tree cover
  - Strong DIZ
  - Weak DIZ
  - Woodland

Rewetted:
- **With restoration effect**
  - **Not overgrown**
  - **Overgrown**
  - **Dense tree layer**
- **Restored**

Restoration effect

Restored

Collected data

- Total (ecosystem) respiration
- Soil heterotrophic respiration
- Soil CH_4, N_2O flux
- Soil/air T, WTL
- water quality (DOC, N, NH4, NO3, PO3, K, Ca, Mg, redox, EC)
- Soil quality (BD, pH, K, Ca, Mg, P + trace elements)
- Fine litterfall, moss production, woody and vascular ground vegetation above and belowground biomass

Vegetation and litter biomass

C efflux measurement results

Measured hetrotrophic respiration, t C ha^{-1} yr^{-1}

Chamber enclosed ecosystem respiration, t C ha^{-1} yr^{-1}
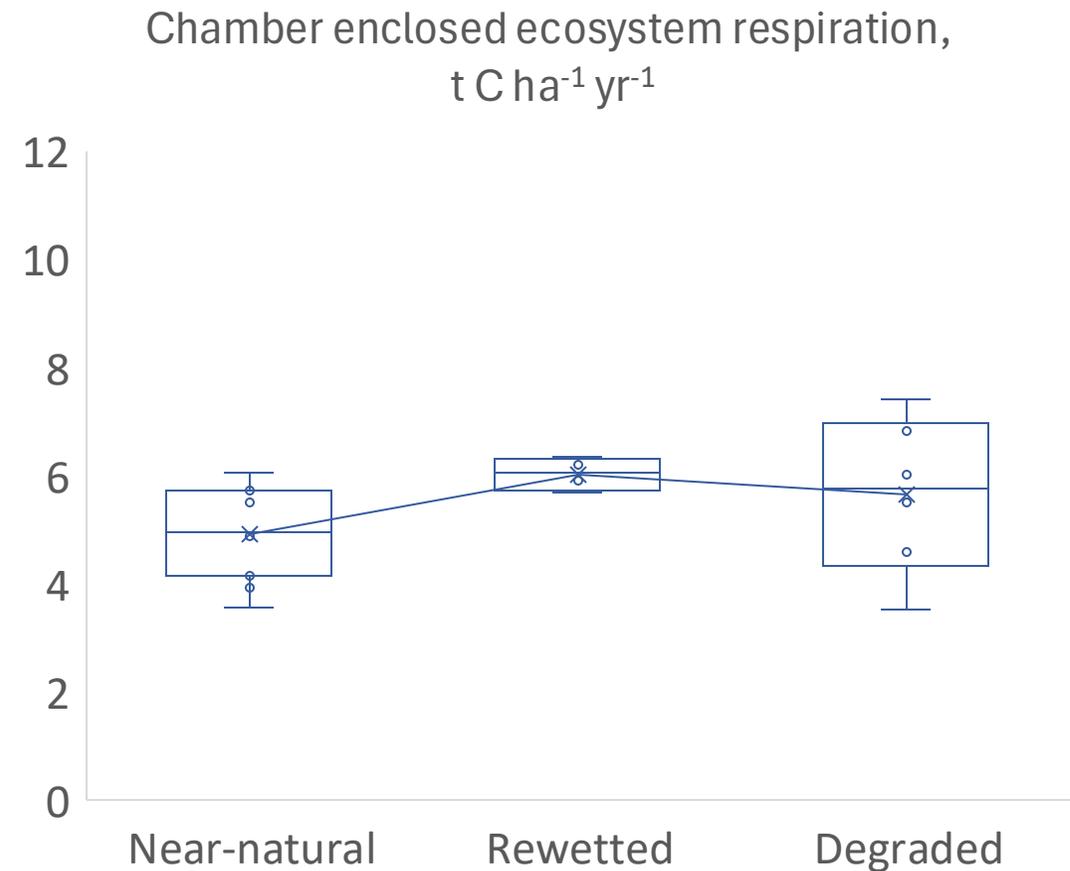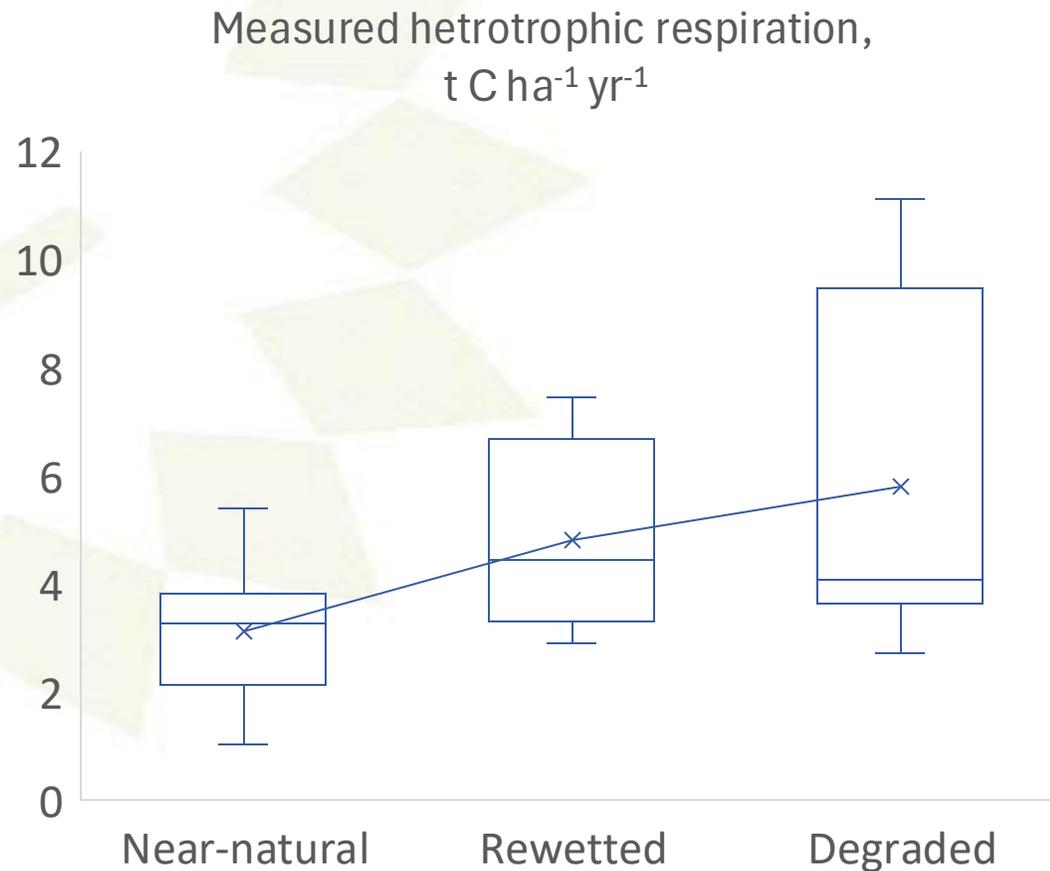
Soil C balance calculation methodological choice
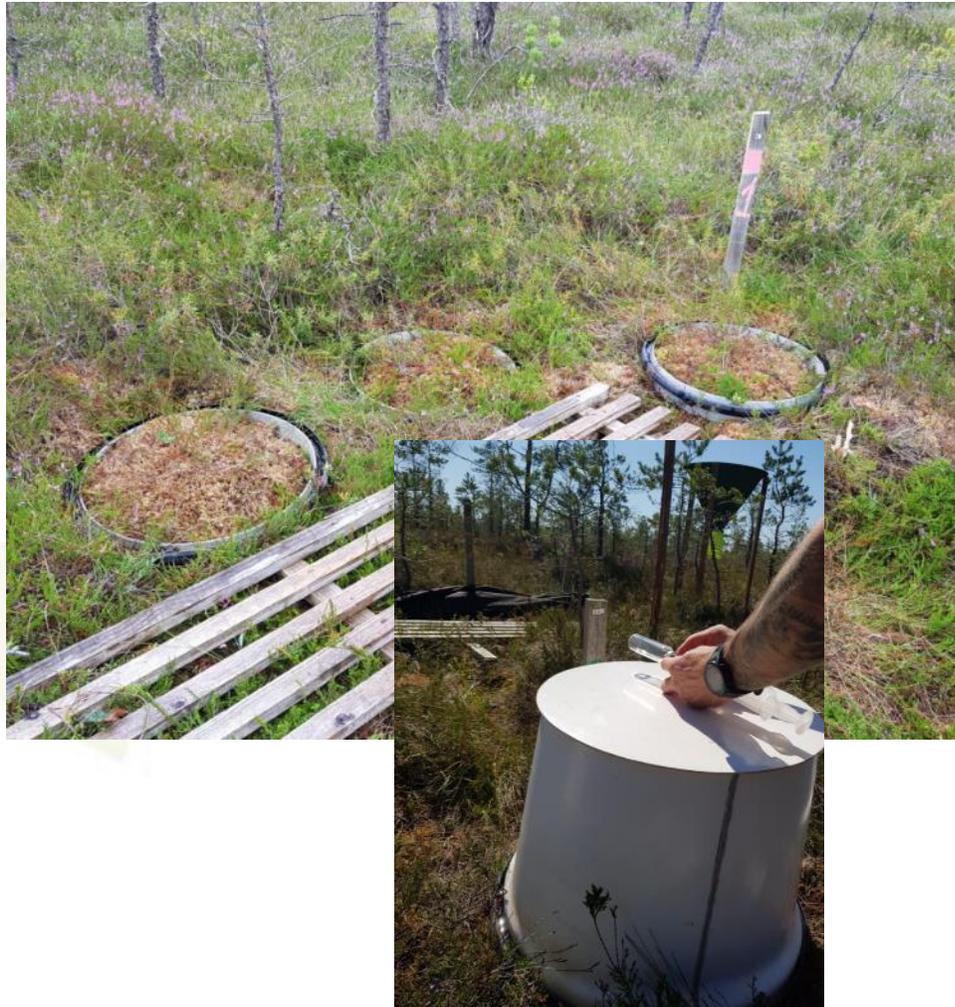
AND/OR

Directly measured Rhet based Soil C balance estimation method

ΔC = (AGVa+AGVp*k1)*k2+BGV*k3+Rhet

where:

ΔC – annual soil C balance

AGVa – annual fine litterfall and moss production, aboveground vascular vegetation peak biomass

AGVp – woody ground vegetation aboveground biomass

BGV – belowground biomass

K1, K3 – turnover rates

K2 – aboveground litter C content to soil C input recalculation coefficient

Rhet – heterotrophic respiration

$$\Delta C_{soil} = L - R_{het} \qquad (1)$$

R_{het} can be measured in extensive studies by using portable soil respiration chambers and upscaled to a countrywide level (Ojanen et al., 2010; von Arnold et al., 2005a). Forest inventory results provide a basis for estimating country level tree and ground vegetation biomass and further L. On the other hand, neither L nor R_{het} can be directly measured. The estimation of belowground L from biomass is based on root turnover rates and these are highly uncertain (e.g. Godbold et al., 2003; Ostonen et al., 2005). R_{het} in turn needs to be separated from forest floor respiration (R_{floor}) that also includes the autotrophic respiration associated with tree roots and with ground vegetation.

https://doi.org/10.1016/j.foreco.2012.04.027

Directly measured Rhet based Soil C balance estimation method assumptions

Biomass turnover rates (https://doi.org/10.14214/df.30.):

- Woody biomass belowground biomass 0.33

- Woody biomass aboveground biomass 0.25

- Vascular plant aboveground biomass 1.0

- Vascular plant belowground biomass 0.33

Fraction of aboveground litter considered as annual C input 0.80 by Confluence of:

- Aboveground litter carbon input by Olson's (1963) model $X=X0e^{(-k \cdot t)}$ (https://doi.org/10.2307/1932179), where t -12, k for vascular plants – 0.2 (10.1029/2008GM000815)
- Yasso20 predicted (https://doi.org/10.5194/bg-20-3827-2023) decomposition rate in the first year according to AWENH for moss and vascular plants [0.65;0.07;0.04;0.24;0] and [0.46;0.32;0.04;0.18]

Rtot to Rhet recalculation based Soil C balance estimation method

ΔC = (AGVa+AGVp*k1)+BGV*k3+Rtot*k2

where:

ΔC – annual soil C balance

AGVa – annual fine litterfall and moss production, aboveground vascular vegetation peak biomass

AGVp – woody ground vegetation aboveground biomass

BGV – belowground biomass

K1, K3 – turnover rates

K2 – Rtot to Rhet recalculation coefficient

Rtot – total respiration

However, it is also possible to utilise R_{floor} measurements and avoid the partitioning of below ground processes. For C input, we then need to estimate the entire flux of photosynthesis-derived C into the forest floor, as R_{floor} is the total CO_2 efflux from the forest floor. Ecosystem photosynthesis (GPP_{eco}) consists of tree stand (GPP_{trees}) and forest floor (GPP_{floor}) photosynthesis. The above ground parts of the tree stand respire a part of the assimilated C (R_{trees_above}) and R_{floor} comprises the rest of the ecosystem respiration (R_{eco}). The change in ecosystem C storage consists of ΔC_{soil} and the changing biomass of tree stand and forest floor vegetation (ΔC_{biom}). Thus, the remainder of GPP_{eco}, after subtracting all respiration fluxes and ΔC_{biom}, accounts for ΔC_{soil} (R_{floor} method):

$$\Delta C_{soil} = [GPP_{trees} + GPP_{floor}] - [R_{trees\_above} + R_{floor}] - \Delta C_{biom} \qquad (2)$$
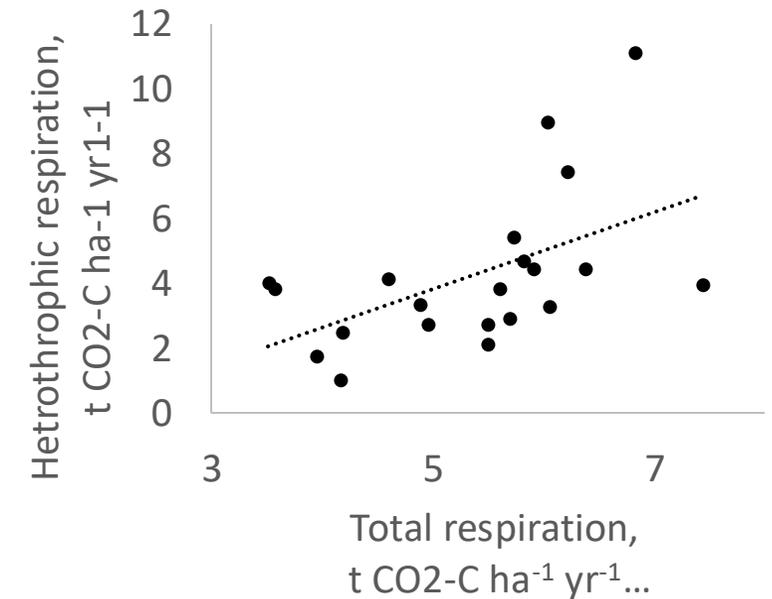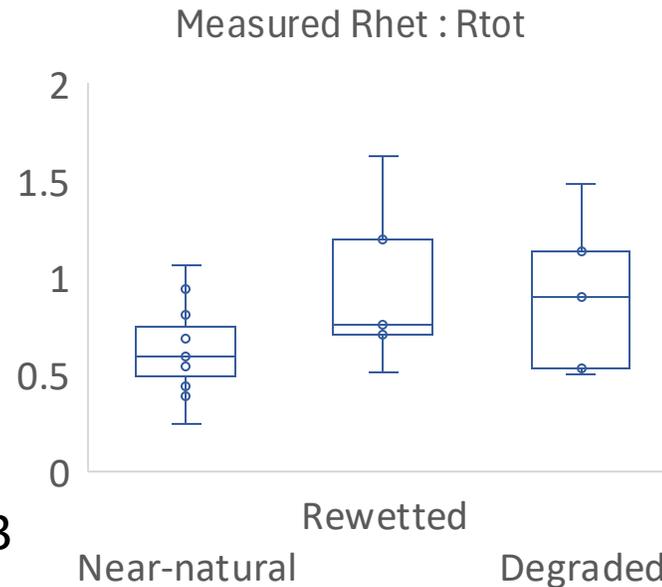
https://doi.org/10.1016/j.foreco.2012.04.027

Rtot to Rhet recalculation based Soil C balance estimation method assumptions

Rtot to Rhet recalculation coefficient 0.5

when T>5 °C:

- Ombrotrophic bogs 0.25
  (https://doi.org/10.3389/feart.2023.1263418)

- raised ombrotrophic bog 0.46
  (https://doi.org/10.1046/j.0022-0477.2001.00633.x)

- Oligotrophic minerogenic mire 0.45
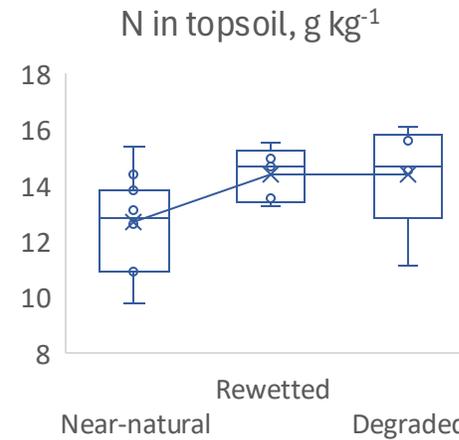 (10.1111/gcb.14292)

- Blanket bog 0.46 – 0.59
  (https://doi.org/10.1016/j.geoderma.2009.09.002)

Belowground biomass turnover rate 0.33
(https://doi.org/10.14214/df.30.)

Measured Rhet : Rtot

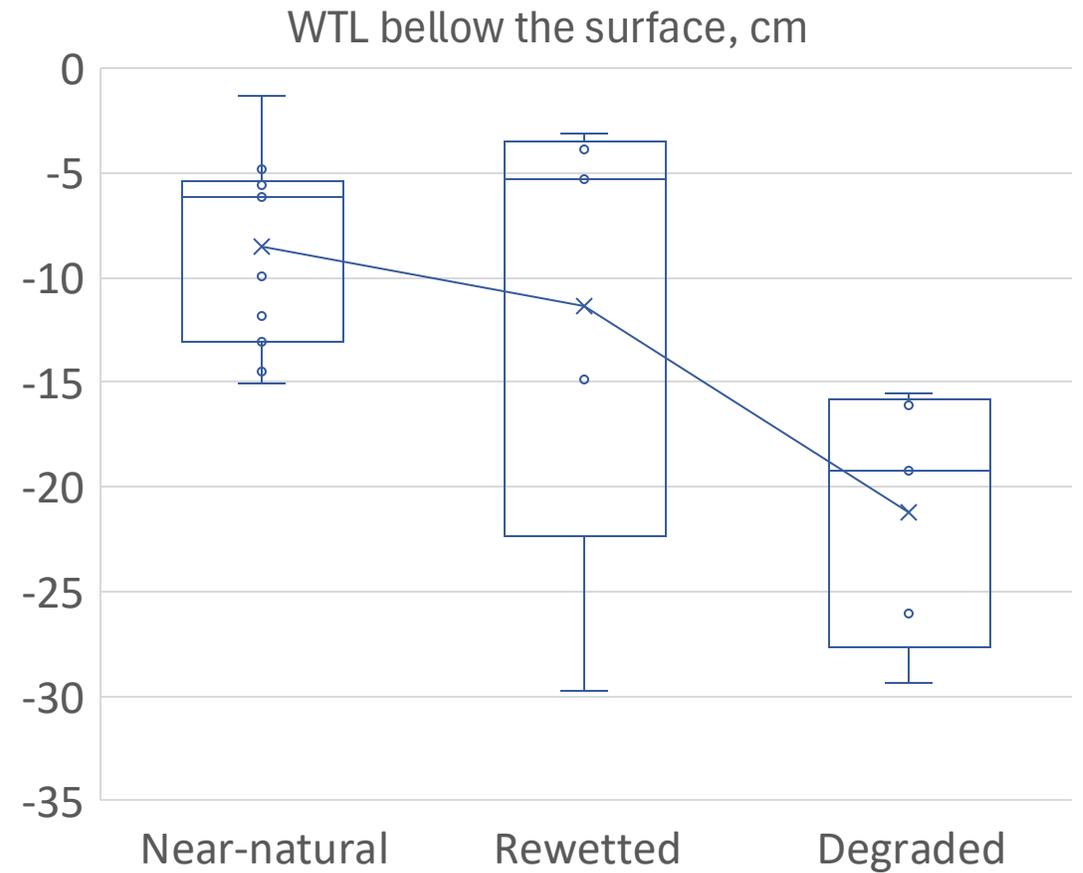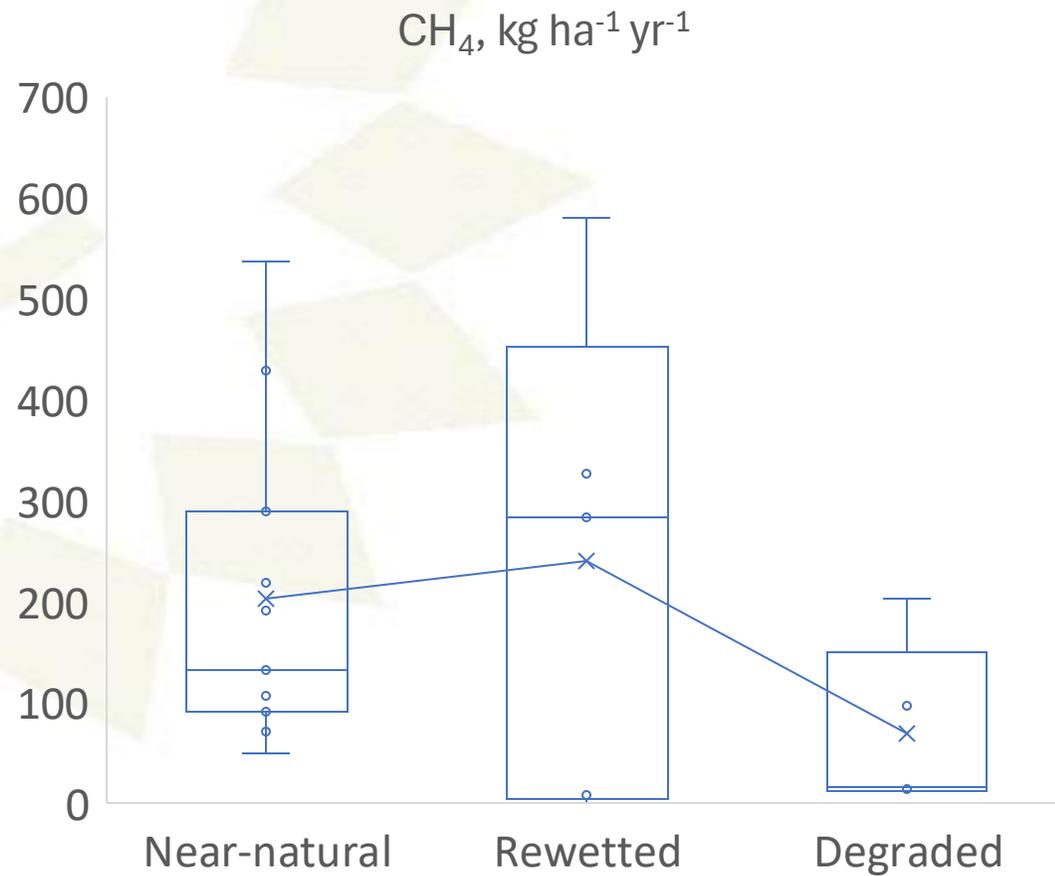# C balance results by both methods

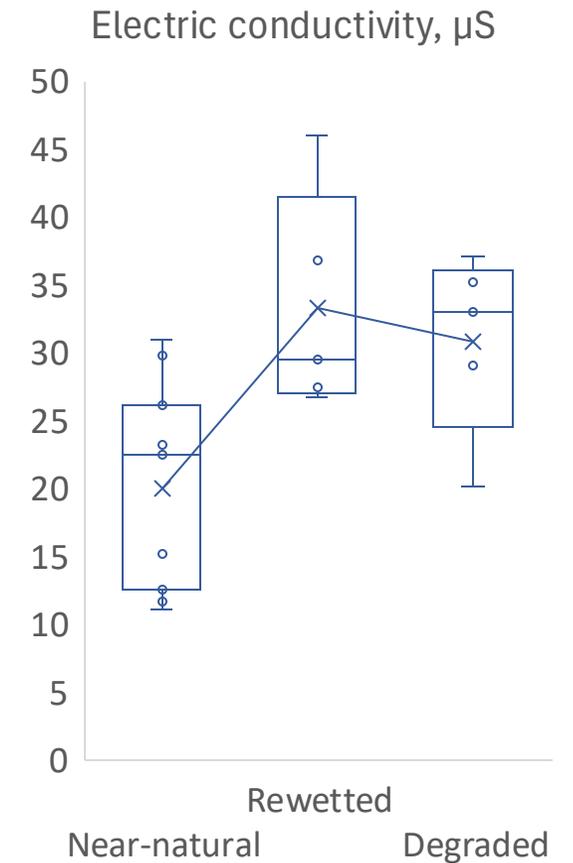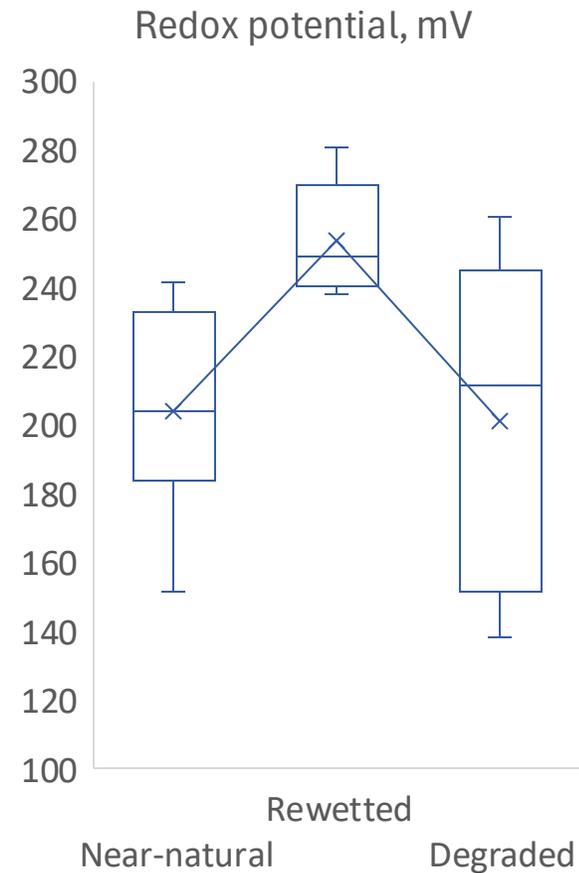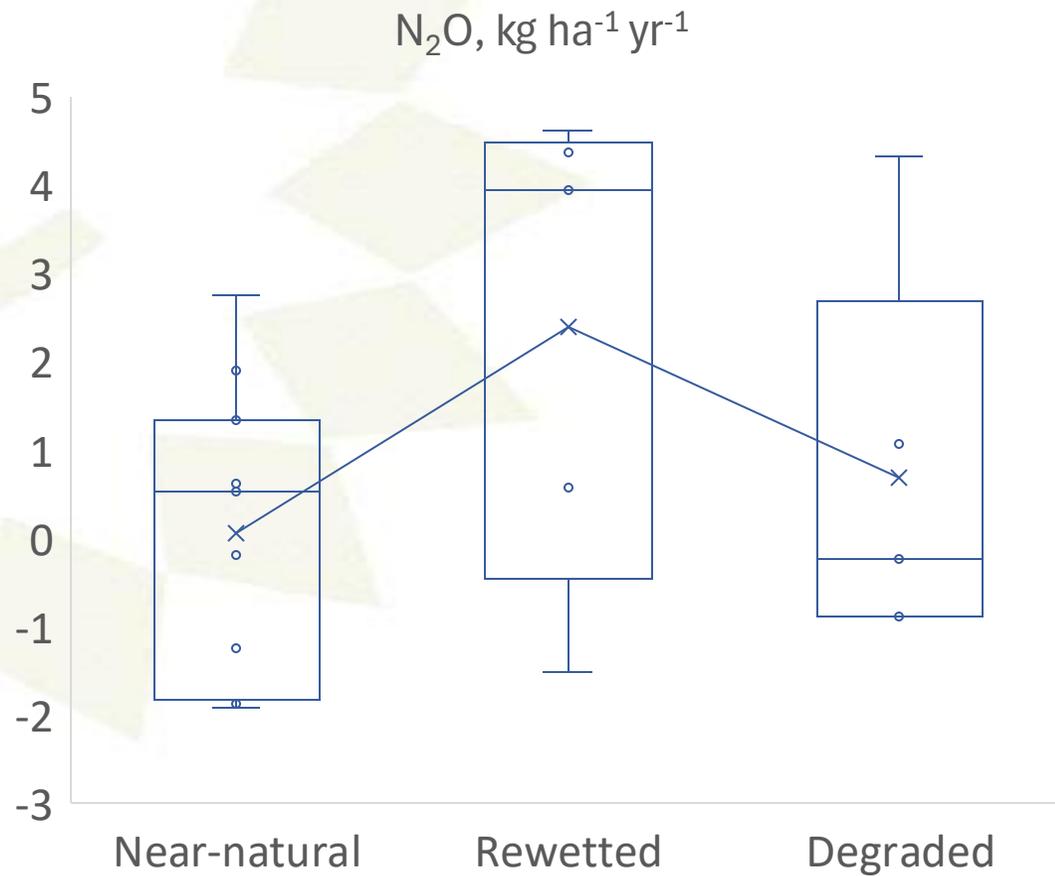net CO_2-C, t ha^{-1} yr^{-1} (by Rhet)
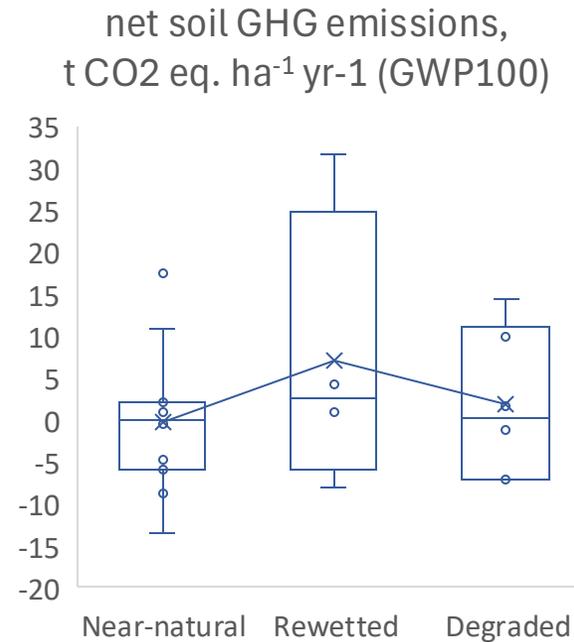
net CO_2-C, t ha^{-1} yr^{-1} (by Rtot)
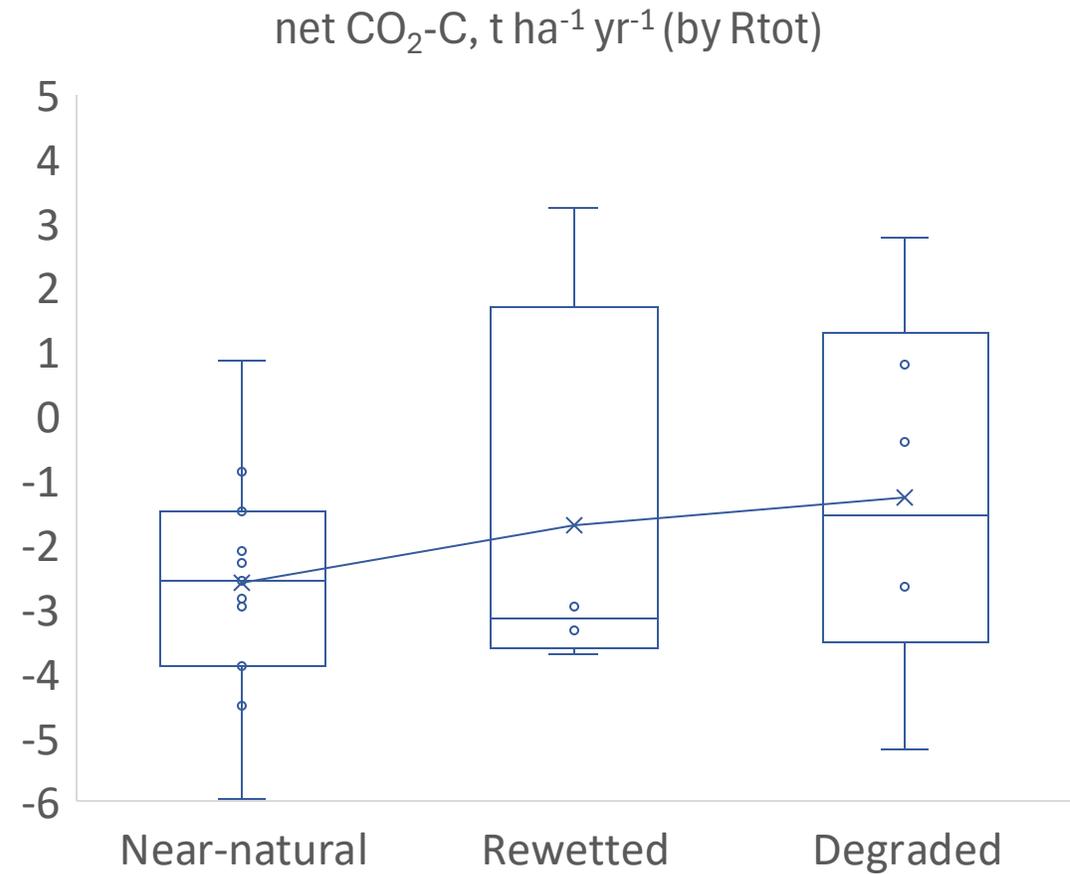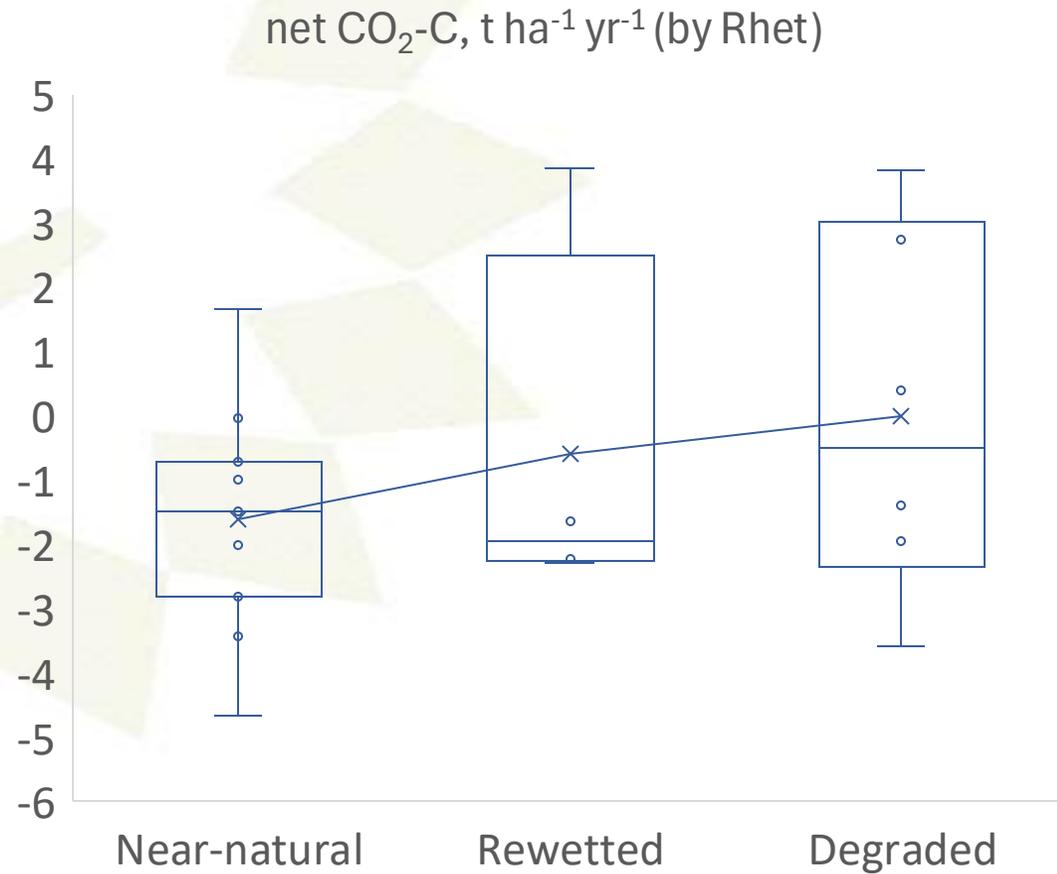
Soil carbon balance and soil properties
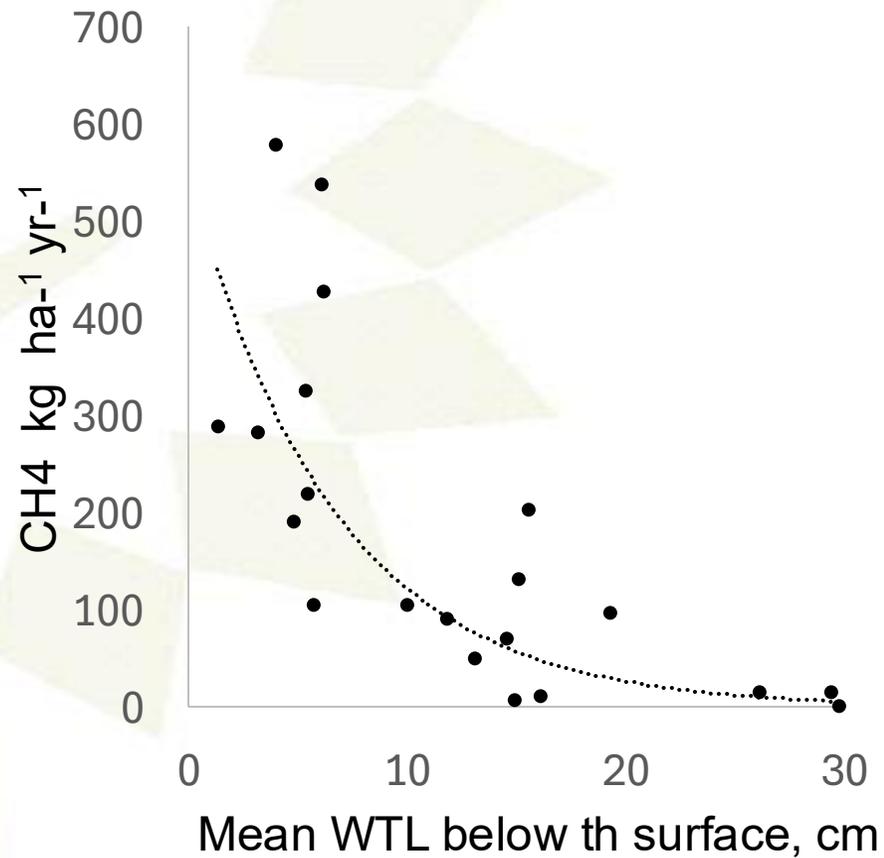

net CO_2-C, t ha^{-1} yr^{-1} (by Rhet)

N in topsoil, g kg^{-1}

P in topsoil, g kg^{-1}

K in topsoil, g kg^{-1}

Topsoil pH

Methane and WTL

CH$_4$, kg ha^{-1} yr^{-1}

WTL bellow the surface, cm

N$_2$O and redox potential

N$_2$O, kg ha^{-1} yr^{-1}

Redox potential, mV

Electric conductivity, µS

Summary

CH4 kg ha⁻¹ yr⁻¹ vs Mean WTL below th surface, cm
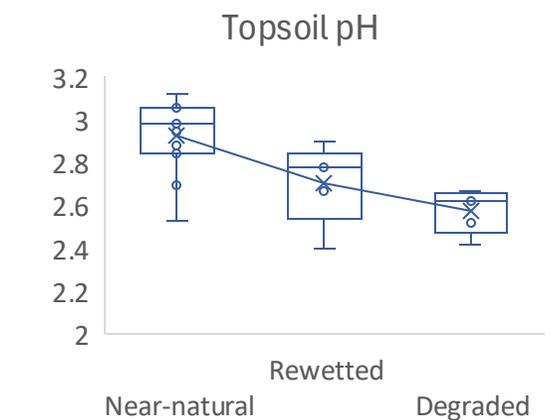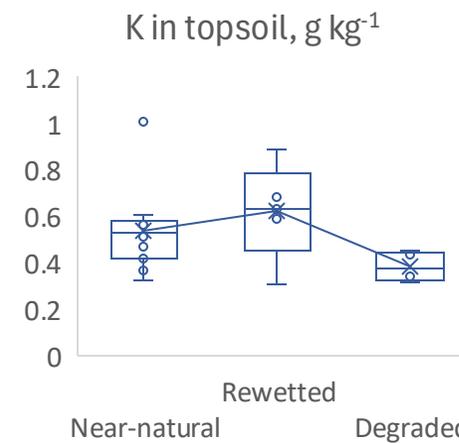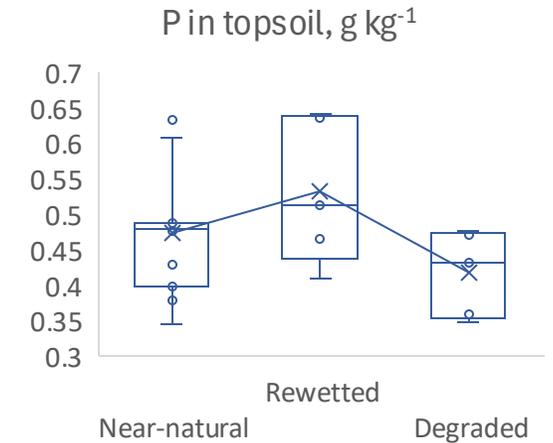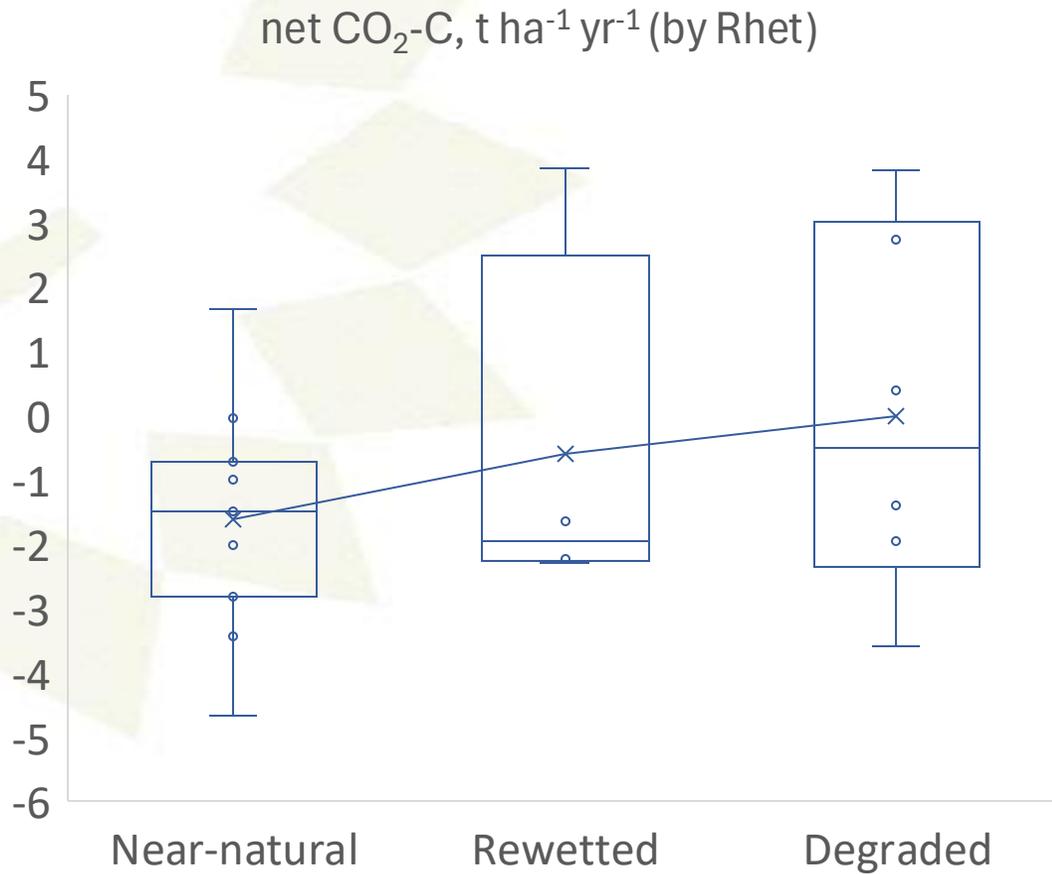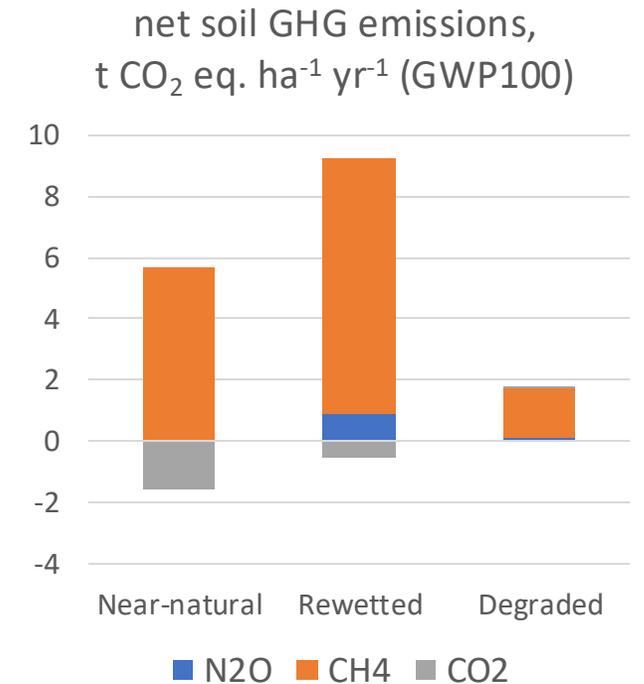
Variation of summed site-specific fluxes

Summed within the category averaged fluxes

Summary

- Estimated soil C balance varies around equilibrium in all site type categories

- Observed gradient of reduced measured soil heterotrophic respiration and increasing estimated sinks in site category direction Degraded → Rewetted → Near-natural

- Reduced degraded soil mineralization rate likely relates to relatively lower nutrient availability (tendency of relatively lower nutrient concentrations and pH) and mean WTL<30cm

- Risk of increased non-CO2 emissions in rewetted sites could be linked to higher WTL variation+nutrient availability, as indicated by the tendency of higher electric conductivity of soil water and increased redox potential